SA... HE LATE IMPROVEMENTS IN STEAM NAVIGATI...

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# LECTURE

ON THE LATE IMPROVEMENTS IN

# STEAM NAVIGATION

AND

# THE ARTS OF NAVAL WARFARE,

WITH A BRIEF NOTICE OF

# ERICSSON'S CALORIC ENGINE:

Delivered before the Boston Lyceum,

BY

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# NOTE.

The following Lecture was prepared for the Boston Lyceum, and was delivered before that Association in December last. Its topics have proved of sufficient interest to induce frequent applications for its repetition, which, in consequence of professional engagements, the writer has been compelled in every instance to decline. He now acquiesces in its publication with reluctance, because it was not originally intended for the press, and must appear with the numerous defects, which in an oral discourse may be readily pardoned, but in the printed page cannot escape censure. The novelty of its materials, however, must compensate, so far as it may, for the rudeness of its execution.

*New-York, May 10th*, 1844.

# LECTURE.

SOME five or six years ago, I was a spectator of the departure of the *Great Western* from the port of New-York, on her first trans-atlantic voyage. The event excited universal interest. Quite a gala day was made on the occasion. When the hour of her departure approached, Castle Garden, and the battery, and the piers in the neighborhood, on the North and East rivers, were crowded with their thousands of curious and anxious spectators. The numerous ships in the harbor displayed their national flags. Scores of sail-boats and row-boats were darting about among the large craft, with which the bay and rivers were alive. When this magnificent vessel started on

her voyage, she was followed by a fleet of steamboats laden with dense masses of human beings, while the floating streamers and gay music animated a scene which is, at all times, one of surpassing natural beauty.

The *Great Western* continued to come and go, with the regularity of the returning months, and her departure had, of course, ceased to be a subject of much more interest than that of an ordinary London packet.

On the 20th of October last, however, between two and three o'clock in the afternoon, the tide of life, that was pouring down Broadway towards the Battery, indicated that some spectacle was anticipated of similar interest with that which I have described. The Battery and the piers were again thronged with an expecting multitude. At her appointed hour, the *Great Western* came ploughing her way down the East river, under circumstances which manifested more than ordinary effort. She was enveloped in clouds of steam, and of dense black smoke; her paddle wheels were revolving with unusual velocity, leaving a white wake behind her, that seemed to cover half the river with foam :—and with her sails all set, she was evidently prepared to do her best in an an-

ticipated race. As she passed the Battery she was greeted with three hearty cheers, and a fair field with no favor was all that she seemed to challenge, and the least that all were willing to allow her.

She had left Castle Garden about a quarter of a mile behind her, when a fine model of a sailing ship, frigate-like, appeared gliding gracefully down the North river, against the tide, without a breath of smoke or steam to obscure her path—with no paddle-wheels or smoke-pipe visible—propelled by a noiseless and unseen agency, without a rag of canvass on her lithe and beautiful spars—but at a speed that soon convinced the assembled thousands that she would successfully dispute the palm with the gallant vessel, celebrated throughout the world, and every where admitted to be the queen of the seas.

Such is the march of improvement in the arts. The new comer was the United States War-Steamer *Princeton*. The agent by which she was moved was ERICSSON'S PROPELLER. She soon reached and passed the *Great Western*, went round her, and passed her a second time before they had reached their point of separation. In a moment, practical men began to speak lightly

of their hitherto favorite paddle-wheel—and the Propeller, that they had shrugged their shoulders at, and amused themselves with for some years of doubtful experiment, rose into altogether unexpected favor.

As confidential personal relations with Captain Ericsson, and an acquaintance with some of his friends, have made me familiar with the incidents of his professional career, I have thought that I could not more agreeably or more usefully occupy the hour allotted to me this evening, than by giving a brief account of an invention that is now exciting so much public interest; with a slight sketch of the man who is destined to rank, from his eminent attainments in the various branches of mechanical philosophy, and from the character and importance of the results he has already accomplished, with the first mechanicians of the age.

The principle of the propeller was first suggested to the inventor, by the analogies of nature, and a study of the means employed to propel the inhabitants of the air and deep. He satisfied himself that all such propulsion in nature is produced by oblique action; though, in common with all practical men, he at first supposed that it was inseparably attended by a loss of power. But

when he reflected that this was the universal principle adopted by the great Mechanician of the universe, in enabling the birds, insects and fishes to move through their respective elements, he knew that he must be in error. This he was soon able to demonstrate, and he became convinced, by a strict application of the laws which govern matter and motion, that no loss of power whatever attends the oblique action of the propelling surfaces applied to Nature's locomotives.

After having satisfied himself on the theory of the subject, the first step of the inventor was the construction of a small model which he tried in the circular basin of a bath in London. The model was fitted with a small engine, supplied with steam by a pipe leading from a steam-boiler over the centre of the bath, and descending to within a foot of the water line, where it was branched off by a swivel joint and connected with the engine in the boat. Steam being admitted in this pipe, the engine in the boat was put in motion, and motion was thus communicated to the propeller. To the great delight of the inventor, so perfectly was his theory borne out in practice, and so entirely were all his anticipations realized, that this model, though less than two feet long,

performed its voyage about the basin, at the rate of upwards of three English miles an hour.

The next step in the invention was the construction of a boat forty feet long, eight feet beam, three feet draft of water, with two propellers each of five feet three inches diameter. So successful was this experiment, that when steam was turned on the first time, the boat at once moved at a speed upwards of ten miles an hour, without a single alteration being requisite in her machinery. Not only did the boat attain this considerable speed, but its power to tow larger vessels was found to be so great, that schooners of one hundred and forty tons burthen were propelled by it at the rate of seven miles an hour; and the American packet ship *Toronto*, under the command of Captain Griswold, was towed in the river Thames by this miniature steamer, at the rate of more than five English miles an hour through the water. This feat excited no little interest among the boatmen of the Thames, who were astonished at the sight of this novel craft moving against wind and tide without any visible agency of propulsion, and ascribing to it some supernatural origin united in giving it the name of the ***Flying Devil.*** But the engineers of London regarded the experiment

with silent neglect: and the subject, when laid before the Lords of the British Admiralty, failed to attract any favorable notice from that august body.

Perceiving its peculiar and admirable fitness for ships of war, ERICSSON was confident that their lordships would at once order the construction of a war-steamer on the new principle. He invited them therefore, to take an excursion in tow of his experimental boat. Accordingly the gorgeous and gilt Admiralty Barge was ordered up to the Somerset House, and the little steamer was lashed along side. The barge contained Sir CHARLES ADAM, senior lord of the Admiralty; Sir WILLIAM SIMONDS, chief constructor of the British Navy; Sir EDWARD PARRY, the celebrated commander of the second North Pole expedition; Captain BEAUFORT, the chief of the Topographical Department of the British Admiralty, and others of scientific and naval distinction. In the anticipation of a severe scrutiny from so distinguished a personage as the chief constructor of the British Navy, the inventor had carefully prepared plans of his new mode of propulsion, which were spread on the damask cloth of the magnificent barge. To his utter astonishment, as we may well imagine, this scientific gentleman

did not appear to take the slightest interest in his explanations. On the contrary, with those expressive shrugs of the shoulder, and shakes of the head, which convey so much to the bystander without absolutely committing the actor,—with an occasional sly, mysterious, undertone remark to his colleagues,—he indicated very plainly that though his humanity would not permit him to give a worthy man cause for so much unhappiness, yet that "he could an if he would" demonstrate by a single word the utter futility of the whole invention.

Meanwhile the little steamer, with her precious charge, proceeded at a steady progress of ten miles an hour, through the arches of the lofty Southwark and London bridges, towards Limehouse, and the steam-engine manufactory of the Messrs. SEAWARD. Their lordships having landed and inspected the huge piles of ill-shaped cast iron, mis-denominated marine engines, intended for some of his Majesty's steamers; with a look at their favorite propelling apparatus, the Morgan paddle-wheel, they re-embarked and were safely returned to the Somerset House, by the disregarded, noiseless and unseen propeller of the new steamer.

On parting, Sir Charles Adam, with a sympathizing air, shook the inventor cordially by the hand, and thanked him for the trouble he had been at in showing him and his friends this *interesting* experiment; adding, that he feared he had put himself to too great an expense and trouble on the occasion. Notwithstanding this somewhat ominous finale of the day's excursion, Ericsson felt confident that their lordships could not fail to perceive the great importance of the invention. To his surprise, however, a few days afterwards, a friend put into his hands a letter written by Captain Beaufort, at the suggestion, probably, of the lords of the Admiralty; in which that gentleman, who had himself witnessed the experiment, expressed regret to state that their lordships had certainly been very much disappointed at its result. The reason for the disappointment was altogether inexplicable to the inventor: for the speed attained at this trial far exceeded any thing that had ever been accomplished by any paddle wheel steamer on so small a scale.

An accident soon relieved his astonishment, and explained the mysterious givings-out of Sir William Simonds, alluded to in our notice of the excursion. The subject having been started at

a dinner table when a friend of Ericsson was present, Sir William ingeniously and ingenuously remarked, that "even if the Propeller had the "power of propelling a vessel, it would be found "altogether useless in practice, *because* the power "being applied in the *stern* it would be *absolute-* "*ly impossible* to make the vessel steer." It may not be obvious to every one how our naval philosopher derived his conclusion from his premises; but his hearers doubtless readily acquiesced in the oracular proposition, and were much amused at the idea of undertaking to steer a vessel when the power was applied in her stern.

But we may well excuse the lords of the British Admiralty for exhibiting no interest in the invention, when we reflect that the engineering corps of the empire were arrayed in opposition to it; alleging that it was constructed upon erroneous principles, and full of practical defects, and regarding its failure as too certain to authorize any speculations even of its success. The plan was specially submitted to many distinguished engineers, and was publicly discussed in the scientific journals; and there was no one but the inventor who refused to acquiesce in the truth of the numerous demonstrations, proving the vast

loss of mechanical power which must attend this proposed substitute for the old-fashioned paddle wheel.

While opposed by such a powerful array of English scientific wisdom, the inventor had the satisfaction of submitting his plan to a citizen of the New World, who was able to understand its philosophy, and appreciate its importance. I allude to a gentleman well known to many of this audience, who have enjoyed his liberal hospitality in a foreign land,—Mr. FRANCIS B. OGDEN, a native of New-Jersey, for many years Consul of the United States at Liverpool, and in that position reflecting the highest credit on the American name and character. Though not an engineer by profession, Mr OGDEN has been distinguished for his eminent attainments in mechanical science, and is entitled to the honor of having first applied the important principle of the expansive power of steam, and of having originated the idea of employing right angular cranks in marine engines. His practical experience and long study of the subject,—for he was the first to stem the waters of the Ohio and Mississippi, and the first to navigate the ocean, by the power of steam alone,—enabled him at once to perceive

the truth of the inventor's demonstrations. And not only did he admit their truth, but he also joined Captain Ericsson in constructing the first experimental boat to which I have alluded, and which the inventor launched into the *Thames*, with the name of the *Francis B. Ogden*, as a token of respect for his transatlantic friend.

Other circumstances soon occurred, which consoled the inventor for his disappointment in the rejection of the Propeller by the lords of the British Admiralty. The subject had been brought to the notice of an officer of the Navy of the United States, who was at that time on a visit to London, and who was induced to accompany the inventor in one of his experimental excursions on the Thames. I allude to Captain Robert F. Stockton, who is entitled to the credit of being the first naval officer who heard, understood, and dared to act upon the suggestions of Ericsson, as to the application of the Propeller to ships of war. At the first glance, he saw the important bearings of the invention, and his acute judgment enabled him at once to predict that it was destined to work a revolution in naval warfare. In those who are not acquainted with the character of Captain Stockton, the great rapidity of his per-

ception, his self-reliance, and the energy with which he prosecutes his purposes—it may excite some surprise to learn, that, after making a single trip in the experimental steamboat, from London bridge to Greenwich, he ordered the inventor to build for him forthwith two iron boats for the United States, with steam machinery and Propeller on the plan of this rejected invention. "I do not want," said Captain Stockton, "the opinions of your scientific men; what I have seen this day satisfies me." It is due to Captain Stockton to state that his whole course in regard to this invention, and the introduction of it into this country, has been in accordance with the spirit of this remark.

At a dinner given on this occasion at Greenwich, Captain Stockton, in his happy style, made several predictions and promises in respect to the new invention, all of which have since been realized. To the inventor, he said in words of no unmeaning compliment, "We'll make your name *ring* on the Delaware, as soon as we get the Propeller there." The Princeton was launched into the Delaware, and the Ericsson Steamboat Line is now carrying nearly the whole of the freight between Philadelphia and Baltimore, and Captain

Stockton's several iron Propeller boats may be seen every day on the Delaware, carrying the rich mineral products of Pennsylvania to the East.

But not only did Captain Stockton order, on his own account, the two iron boats to which I have referred; he at once brought the subject before the Government of the United States, and caused numerous plans and models to be made at his own expense, explaining the peculiar fitness of the new invention for ships of war. So completely persuaded was he of its great importance in this aspect, and so determined that his views should be carried out, that he boldly assured the inventor that the Government of the United States would test the Propeller on a large scale; and so confident was Ericsson that the perseverance and energy of Captain Stockton would sooner or later accomplish what he promised, that he at once abandoned his professional engagements in England, and set out for the United States. Circumstances delayed, for some two years, the execution of their plan. With the change of the Federal administration, Captain Stockton was first able to obtain a favorable hearing; and under the auspices of the present

administration, the experiment of the *Princeton* has been made, and has been successful.

It is due to the inventor to mention that the Propeller, as successfully applied in the *Princeton,* is the same precisely in construction with that of the *Francis B. Ogden;* not merely in theory, but in its minute practical details. There is now a Propeller in the Phœnix Foundry, in New-York, brought over by Captain Ericsson, in the *British Queen,* in 1839, which, in all its essential parts, is a fac-simile of that in the *Francis B. Ogden,* and of that in the *Princeton.*

The circumstances then, under which this invention was devised and prosecuted, the perseverance with which it was followed up by Ericsson, through all discouragement and neglect, and its ultimate success in its *precise original shape,* prove it to have been the result, not of a happy accident, but of patient reflection and scientific calculation. It was not *hit upon,* but was wrought out; it was not suggested, but elaborated; demonstrated in theory to the inventor's own satisfaction, before it was submitted to the test of a successful experiment.

In further illustration of this fact, and before proceeding to give a more particular account of

the *Princeton* and the Propeller, I will present a brief personal sketch of the inventor, that cannot fail to possess the interest of novelty, at least, to all; and may gratify such of the audience as indulge a natural curiosity in tracing the progress of a professional career, from its dawn to its meridian, without waiting for its close.

JOHN ERICSSON was born in 1803, in the Province of Vermeland, among the iron mountains of SWEDEN. His father was a mining proprietor, so that the youth had ample opportunities to watch the operation of the various engines and machinery connected with the mines. These had been erected by mechanicians of the highest scientific attainments, and presented a fine study to a mind of mechanical tendencies. Under such influences, his innate mechanical talent was early developed. At the age of ten years, he had constructed with his own hands, and after his own plans, a miniature saw-mill; and had made numerous drawings of complicated mechanical contrivances, with instruments of his own invention and manufacture.

In 1814, he attracted the attention of the celebrated Count PLATEN, who had heard of his boyish efforts, and desired an interview with him.

After carefully examining the various plans and drawings which the youth exhibited on this occasion, the Count handed them back to him, simply observing in an impressive manner, "Continue as you have commenced, and you will one day produce something extraordinary." Count PLATEN was the intimate personal friend of BERNADOTTE, the King of Sweden, and was regarded by him with a feeling little short of veneration. It was Count PLATEN who undertook and carried through, in opposition to the views of the Swedish nobility, and of nearly the whole nation, that gigantic work, the Grand Ship Canal of SWEDEN, which connects the North Sea with the Baltic. He died Viceroy of NORWAY, and left behind him in the North of Europe, the reputation of one of the greatest men of the century. The few words of kind encouragement, which he spoke on the occasion to which I have referred, sunk deeply into the mind of the young mechanician, and confirmed him in the career on which he had entered.

Immediately after this interview, young ERICSSON was appointed a cadet in the corps of engineers, and, after six months' tuition, at the age of twelve years, was appointed *nivelleur* at the

Grand Ship Canal, under Count Platen. In this capacity in the year 1816 he was required to set out the work for more than six hundred men. The canal was constructed by soldiers. He was at that time not tall enough to look through the levelling instrument; and in using it he was obliged to mount upon a stool, carried by his attendants for that purpose. As the discipline in the Swedish army required that the soldier should always uncover the head in speaking to his superior, gray-headed men came, cap in hand, to receive their instructions from this mere child. While thus employed in the summer months, he was constantly occupied during the winter with his pencil and pen; and there are many important works on the canal constructed after drawings made by Ericsson at this early age. During his leisure hours he measured up, and made working drawings of every implement and piece of machinery connected with this great enterprise; so that at the age of fifteen, he was in possession of accurate plans of the whole work drawn by his own hand.

His associations with military men on the canal had given him a tendency for military life, and at the age of seventeen he entered the Swedish

army as an ensign, without the knowledge of his friend and patron Count Platen. This step excited the indignation of the count, who tried to prevail upon him to change his resolution; but finding all his arguments useless, he terminated an angry interview by bidding the young ensign to "go to the devil." The affectionate regard which he entertained for the count, and gratitude for the interest taken by him in his education, caused the circumstances of this interview to make a deep impression upon Ericsson, but were not sufficient to shake his determination.

Soon after the young ensign had entered upon his regimental duties, an affair occurred which threatened to obscure his hitherto bright prospects. His colonel, Baron Koskull, had been disgraced by the King, about the time that he had recommended Ericsson for promotion. This circumstance induced the king to reject the recommendation. The colonel was exceedingly annoyed by this rejection, and having in his possession a military map made by the expectant ensign, took it to his Royal Highness the Crown Prince Oscar, and besought him to intercede for the young man with the King. The Prince received the map very kindly, expressing great ad-

miration of its beautiful finish and execution, and presented himself in person with it to the King, who yielded to the joint persuasion of the Prince and the map, and promoted the young ensign to the lieutenancy for which he had been recommended.

About the time of this promotion, the Government had ordered the Northern part of SWEDEN to be accurately surveyed. It being the desire of the King that officers of the army should be employed in this service, ERICSSON, whose regiment was stationed in the Northern highlands, proceeded to *Stockholm,* for the purpose of submitting himself to the severe examination then requisite to precede the appointment of Government surveyor. The mathematical education, which he had received under Count PLATEN, now proved very serviceable. He passed the examination with great distinction, and in the course of it to the surprise of the examiners, showed that he could repeat EUCLID verbatim; not by the exercise of the memory, which in ERICSSON is not remarkably retentive, but from his perfect mastery of geometrical science. There is no doubt that it is this thorough knowledge of geometry, to

which he is indebted for his clear conceptions on all mechanical subjects.

Having returned to the highlands, he entered on his new vocation with great assiduity; and, supported by an unusually strong constitution, he mapped a larger extent of territory in a given time than any other of the numerous surveyors employed on the work. There are yet in the archives of SWEDEN, detailed maps of upwards of fifty square miles made by his hand. Neither the great labors attending these surveys, nor his military duties, could give sufficient employment to the energies of the young officer. He now commenced the arduous task of compiling a work on canals, to be illustrated by sixty-four large plates, representing the various buildings, machines and instruments, connected with the construction of such works. The part assigned to him in this enterprise was nothing less than that of constructing all the drawings, as well as of engraving the numerous plates; and as all the plates were to be executed in the style of what is called machine-engraving, he undertook to construct a machine for the purpose, which he successfully accomplished. This work he prosecuted with so much industry in the midst of his other

various labors, that, within the first year of its commencement he had executed eighteen large plates, which were pronounced by judges of machine-engraving to be of superior merit.

His associate in this undertaking was a German engineering officer, Major Pentz, who wrote the text in the German language in preference to the Swedish, in order to secure a wider circulation. Other labors prevented the immediate completion of this work; and so rapid is the improvement in civil engineering, that the lapse of a very few years, from the time of the intended publication, would have rendered it of but little practical utility.

While thus variously occupied, being on a visit to the house of his colonel, Ericsson on one occasion showed his host, by a very simple experiment, how readily and by what simple means mechanical power may be produced, independently of steam, by condensing flame. His friend, being himself a lover of the sciences, was much struck by the beauty and simplicity of the experiment, and prevailed upon Ericsson to give more attention to a principle which he considered highly important. The young officer accordingly made some experiments on an enlarged scale,

and succeeded in the production of a motive power equal to that of a steam-engine of ten horse. So satisfactory was the result of these experiments, from the compact form of the machine employed, as well as the comparatively small consumption of fuel, that he conceived the idea of at once bringing it out in ENGLAND, the great field for all mechanical inventions.

ERICSSON accordingly, through his colonel, obtained leave from the King to visit ENGLAND, where he arrived on the eighteenth of May, 1826. He there proceeded to construct a working engine on the principle to which I have referred; but soon discovered that his *Flame Engine*, when worked by the combustion of *mineral* coals, was a different thing from the experimental model he had tried in the highlands of SWEDEN, with fuel composed of splinters of fine pine wood. Not only did he fail to produce an extended and vivid flame, but the intense heat of the *mineral* coals so seriously affected all the working parts of the machine, as soon to cause its destruction. These experiments, it may well be supposed, were attended with no trifling expenditure; and, to meet their demands upon him, our young adventurer

was compelled to draw on his mechanical resources.

Invention now followed invention in rapid succession, until the records of the Patent Office, in London, were enriched by the drawings of the remarkable steam-boiler on the principle of *artificial draft;* to which principle we are mainly indebted for the benefits conferred on civilized life by the present rapid communication by railways. In bringing this important invention before the public, ERICSSON thought it advisable to join some old and established mechanical house in London, and accordingly he associated himself with JOHN BRAITHWAITE, a name favorably known in the mechanical annals of ENGLAND. This invention was hardly developed, when a favorable opportunity was presented for testing it in practice. The directors of the Liverpool and Manchester railway, before erecting the stationary engines by which they had intended to draw their passenger and freight carriages, determined to appeal to the mechanical talent of the country, in the hope of securing some preferable mode of transit. A prize was accordingly offered in the fall of 1829, for the best locomotive engine, to be tested on the small

portion, at that time completed of the railway. Sufficient publicity not having been given to their advertisement, Ericsson was not aware that any such prize had been offered, until within seven weeks of the day fixed for the trial. Unwilling to permit the occasion to escape him, he was not deterred by the shortness of the time, but, applying all his energies to the task, planned the engine, executed the working drawings, and caused the patterns to be made, and the whole machine completed within the seven weeks. The day of trial arrived. The competing engines were on the ground, and the novelty of the race had attracted an immense concourse of people. Both sides of the railway, for more than a mile in length, were lined with thousands of spectators. There was no room for jockeying in such a race, for inanimate matter was to be put in motion, and that moves only in accordance with immutable laws. The signal was given for the start. Instead of the application of whip and spur, the gentle touch of the steam-valve gave life and motion to the novel machine. Up to that period, the greatest speed at which man had been carried along the ground, was that of the race-horse; and no one, of the multitude present on this

occasion, expected to see that speed surpassed. It was the general belief that the maximum attainable by the locomotive engine, would not much exceed ten miles. To the surprise and admiration of the crowd, however, the *Novelty* steam carriage, the *fastest* engine started, guided by its inventor, ERICSSON, assisted by JOHN BRAITHWAITE, darted along the track at the rate of upwards of fifty miles an hour!

The breathless silence of the multitude was now broken by thunders of hurras, that drowned the hiss of the escaping steam and the rolling of the engine wheels. To reduce the surprise and delight excited on this occasion to the universal standard,—and as an illustration of the extent to which the value of property is sometimes enhanced by the success of a mechanical invention,—it may be stated that when the *Novelty* had run her two miles and returned, the shares of the Liverpool and Manchester railway had risen *ten per cent.*

But how easily may the just expectations of an inventor be disappointed!—Although the principle of the steam-boiler which gave to the *Novelty* engine such decided superiority in speed, is yet retained in all locomotive engines,—I mean the prin-

ciple of *artificial draft;* yet the mode of producing this draft in our present engines is far different from that introduced by ERICSSON, and was discovered by the merest accident; and so soon was this discovery made, after the successful display of the Novelty engine, that the inventor had no time to derive the least advantage from its introduction.

To him, however, belongs the credit of having first disproved the correctness of the once established theory, that, it was absolutely necessary that a certain *extensive* amount of *surface* should be exposed to the fire, to generate a given quantity of steam. The remarkable lightness and compactness of the new boiler, invented by ERICSSON, have led to the employment of steam in many instances in which it had been previously inapplicable. Among these I would only mention the steam fire-engine constructed by him in conjunction with Mr. BRAITHWAITE, about the same time with the Novelty, and which excited so much interest in London at the time the Argyle Rooms were on fire. A similar engine of greater power was subsequently constructed by ERICSSON and BRAITHWAITE, for the King of PRUSSIA, which was mainly instrumental in saving

several valuable buildings at a great fire a few years ago at *Berlin*. For this invention Ericsson received, in 1842, the large gold medal offered by the Mechanics' Institute of New-York, for the best plan of a steam fire-engine.

It would not consist with the limits or the design of this Lecture, to mention the numerous inventions devised by Captain Ericsson during his residence in England,—my main object being to describe, very briefly, the Propeller in its application to ships of war. In natural connection with which, I shall take occasion to comment on an invention which has been for many years the favorite project and study of Captain Ericsson, and the perfecting of which will confer inestimable benefits on mankind.

Before resuming the topic with which I commenced, and returning to the spectacle which suggested the Lecture of this evening, I will attempt a slight description of the mechanical construction of the Propeller, and notice some of the objections to it which have been suggested during the many years of opposition, ridicule and neglect, through which it has been forcing its way into public use.

The Ericsson Propeller is composed of a

series of spiral plates attached to the outside circumference of a short cylinder; which is supported by two or more winding or twisted spokes. The mere description suggests very obvious differences between this machine and the Archimedian Screw, which is simply a thread or spiral blade coiled round an axis; and yet the error prevails extensively that the two are one and the same thing. The Propeller is placed at the stern of the vessel, and instead, of revolving in a plane parallel to the keel, like the ordinary paddle-wheel, it moves in a plane at right angles, on a shaft or axis parallel to the keel. In all vessels having a large draft of water, the Propeller acts entirely below the surface; and in vessels of a light draft, it is only partially immersed.

I have already stated that the principle of Ericsson's Propeller is that of oblique action; very much resembling the action employed by nature in her various contrivances of propulsion through the air and water, such as in the wings of birds and insects, and in the tails of fishes. But though this general similarity exists between the oblique action in the propelling surfaces of this machine, and that of the propelling surfaces alluded to in nature, yet there is this important

difference; that, whilst there is a reciprocating movement given to them by the latter, a rotary movement is given to them in the Propeller.

But if this mode is preferable, why has it not been employed by nature? It is obvious that, in an animal, the rotary movement would twist and destroy the blood vessels and integuments connecting the propelling apparatus to the main body, and cannot, therefore, be employed. Human contrivance, however, may well have the advantage over that of nature in a single aspect. The one thing for which it is designed, and that only, it can execute; whilst the motive machines of nature are capable of discharging a thousand functions at the same time.

It has formed a popular objection to the Propeller, that there is a loss of power unavoidably consequent on the oblique action. It is a well established principle in hydrostatics, that the force of fluids is always directed at right angles to the surface on which it acts. From this it follows that the force of the water, exerted against the oblique plates of the Propeller, depends upon the superficial measurement. It may at once be admitted that the *whole* amount of the force thus acting on the plates, will not, in consequence of

their oblique position, be exerted in urging the vessel ahead. Now, this admission, to an unreflecting observer, might lead to the conclusion that there is a loss of power; but the same reasoning, which shows that the vessel is not urged ahead by the whole force exerted on the plates, likewise proves that this whole force does not counteract the power of the engine employed in turning the Propeller. The erroneous conclusion, then, as to the loss of power, arises from overlooking this important fact; for, in the ratio that the propelling force imparted to the vessel is less than the actual pressure on the plates, in the very same ratio will the engine power requisite to turn the Propeller be less than the force of the water exerted against the plates.

It has been asserted by many engineers of reputation, that the centrifugal tendency produced by the revolution of the Propeller, would cause the water constantly to recede from the centre, and thereby render the propelling surfaces inefficient. This tendency the inventor of the Propeller has obviated, by the introduction of the short cylinder, or broad hoop, to which the spiral plates are attached. The water tending to fly off from the centre is effectually intercepted by this hoop.

In the *Princeton*, the cylinder of the Propeller is eight feet in diameter, and twenty six inches long; and the extreme diameter described by the outer edges of the spiral plates is fourteen feet. It is manufactured wholly of composition metal, the copper of the vessel, in connection with the sea water, exciting a galvanic action which corrodes iron and renders it inapplicable for this purpose.

The steam machinery of the *Princeton* is quite as worthy of observation as her Propeller. It is evidently not enough, in a ship of war, that the Propeller alone should be placed below the water line; it is indispensable that the whole machinery should be placed out of the reach of shot. The ordinary steam engine is too bulky to admit of this location, and Captain Ericsson has invented and constructed an engine upon a novel principle, by which he has been able to effect this most desirable object. Any one, of skill or knowledge in mechanics, will be instantly struck by this beautiful engine as the most remarkable feature in the ship; in view of the vast power that it embodies in so small a compass, and the perfect symmetry and exquisite proportions of all its working parts. It has been patented

in ENGLAND, and in this country, by Captain ERICSSON, under the name of the semi-cylindrical steam-engine. It differs from other engines in the construction and operation of its working cylinders. In the place of complete cylinders, semi-cylinders are employed; the pistons of which, instead of being circular, and traversing from end to end of the cylinder, consist of parallelograms, having a radial or vibrating movement, similar to that of a pendulum, the centre of motion being the centre of these semi-cylinders. The semi-cylinders, are placed longitudinally in the very bottom of the vessel, and parallel to the line of keel. Motion is given to the propeller-shaft by means of short connecting rods, attached to vibrating crank levers on the axes of the vibrating pistons; and the latter are made to reciprocate by the admission of steam, alternately, on opposite sides, as in ordinary engines.

This semi-cylindrical engine of ERICSSON marks an epoch in the history of steam-engines. It is so compact that it occupies only one eighth of the bulk of the British marine engine of corresponding power, and is less than one half the weight. By a peculiar construction, the moving parts have been rendered so extremely light, that

the quantity of matter to be kept in motion is hardly one sixth that of the engine to which I have alluded. This lightness and simplicity of arrangement enable Ericsson to give a *direct* movement to the propeller-shaft, without the intervention of cog wheels and other gear for multiplying the speed, resorted to in the *Great Britain* steam-ship, and indispensable in all steamers propelled by the Archimedian screw. The engines of the *Great Britain*, owing to their cumbrous nature, must be worked at a speed only one fourth that of the screw—that is the screw will perform four revolutions to one of the engine.

The next peculiarity to be noticed in the *Princeton* is the absence of the ordinary tall smoke pipe, employed to produce the draft for keeping up combustion in the furnaces of the boilers. The smoke-pipe has hitherto formed an insuperable objection to a steamer as a ship of war; for the moment that it is carried away, the efficiency of the engines ceases from want of steam. The draft in the boilers of the *Princeton* is promoted by means of blowers placed in the bottom of the vessel, and is quite independent of the *height* of the smoke-pipe, which is only carried

about five feet above the deck of the ship. If this inconsiderable projection should become partially deranged by a shot, the draft kept up by the blowers will continue as efficient as before.

It is not out of place here to observe, that Ericsson was the first to apply to marine engines centrifugal blowers, now so common in this country in all boilers using anthracite coal. In the year 1831 he applied such a blower, worked by a separate small steam-engine, to the steam-packet *Corsair* of one hundred and twenty horse power, plying between Liverpool and Belfast.

But Captain Ericsson has not merely furnished the *Princeton* with this efficient and secure means of propulsion, he has also furnished her with instruments which tend to render the large guns introduced by Captain Stockton extremely formidable ordnance. The *Princeton* has two of these guns. One of them was made in England, and is of about seven tons weight; the other was forged by Ward & Co., and finished at the Phœnix Foundry in the city of New-York. The latter is said to be the largest piece of wrought iron in the world. It weighs ten tons, has a bore of twelve inches, and carries a ball of two hundred and thirteen pounds.

Powerful as this gun is from its large calibre, yet it would obviously be of little practical use without the means of handling, managing and directing it; and such means have been devised by the same mind which conceived the Propeller and the steam engine of the *Princeton*. These are a carriage of peculiar construction; a novel lock; and an instrument for measuring distances at sea. The carriage obviates the difficulties arising from the immense recoil of the gun, and renders it, notwithstanding its vast weight, readily manageable by a small number of hands. It is made of wrought-iron.

The lock to which I have referred is constructed on principles by which the common law of gravitation, in connection with the rolling of the sea, is made subservient in discharging the gun at any desired elevation without human interference. The idea of this lock occurred to Captain Ericsson in the year 1828, and he then constructed one which was exhibited to the head of the British Ordnance Department, Sir Henry Vane. This gentleman was very much struck with the important object of the invention, and offered to appoint a board of officers to test it in practice, and to report upon it. But as the test could not be

satisfactorily applied without divulging the secret of the invention, Captain Ericsson desired to have an agreement executed, binding the government to make him a suitable remuneration, in the event of the trial proving successful. Such a course did not coincide altogether with the views of Sir Henry Vane, and the inventor declined further negociation; preferring to lock up his instrument in an iron safe, where it remained until the year 1839, when his acquaintance with Captain Stockton induced Ericsson to believe him the proper person to bring out the invention. Nor was he deceived, for Captain Stockton saw at a glance its whole practical bearing and importance. This lock will be applied to the large wrought iron guns of the *Princeton*, and cannot fail, I am assured, to direct them with unerring certainty even in a heavy seaway.

Of the distance instrument I must say a word. The point-blank range of a gun, it is well known, is very limited; and consequently when the enemy is at a distance exceeding half a mile, it becomes necessary to give a certain elevation to the gun, in order to counteract the effect of gravitation on the ball. This elevation depends entirely on the distance of the object to be aimed at; and

unless that be accurately known, the proper elevation cannot be given with any degree of accuracy. Various contrivances have been from time to time suggested by naval men, for measuring distances at sea, but hitherto the result has been mere guess-work. The fertility of ERICSSON'S mechanical genius has, however, at length accomplished this great desideratum, by an instrument calculated to measure all distances at sea from four hundred and fifty to four thousand yards. It is based upon unerring and simple mathematical principles, and enables the observer to measure any required distance in a few seconds; and the result being read off by inspection, there is no liability of error.

In view then of the many advantages possessed by the *Princeton,* I will recur to the spectacle, with the delineation of which I commenced this Lecture, and indulge for a moment in the reflections and speculations which it naturally suggests. In the way of steam-navigation, the *Great Western* is thus far the boast of European skill and science. Neither the government of FRANCE nor of ENGLAND, with their immense steam-navies, has produced anything superior in speed, beauty or security. And yet, how comparatively cum-

brous, unmanageable and exposed, are her steam-machinery and her paddle-wheels! A single shot well directed would destroy her capacity of propulsion by steam, and leave her at the mercy of the elements. Thus crippled, her sole dependence must be upon her canvass, and in a calm she would lie an idle hulk upon the waters; and with wind, her canvass would be of little use to her, while oppressed by the dead weight of her fuel and machinery, and retarded by the resistance of her motionless paddle-wheels. And what is true of the *Great Western* is equally true of whole fleets of steamers that have been constructed, by the governments of Europe, with a partial view to objects of commerce and communication, but with the ulterior and contingent purposes of aggressive or defensive warfare.

Turn now to the *Princeton*, and look at her, not with reference to her armament, which in this aspect is of secondary interest, but to her means of propulsion alone. Her steam-machinery and propelling apparatus are placed entirely below the water line; while the contrivance, by which motion is communicated to the Propeller, is so simple as almost to preclude the possibility of derangement, and is inaccessible to any external

agent of injury. Strip her of sails and yards, cut down her masts, riddle her hull with shot, lay her bare fore and aft to the water-line—her engine still remains uninjured, the boiler still generates steam, and her moving power still continues undiminished. It is universally admitted that the introduction of steam upon the ocean, will produce a great change in maritime warfare; but the principles developed in the *Princeton* will work an entire revolution.

Steamers as hitherto constructed, may be well enough employed in maintaining communication between distant shores and distant fleets, or in towing ships of war into position, but they are not capable of mingling in the combat. It is difficult, however, to imagine a more formidable or more safe machine of warfare than the *Princeton*. Not only can she act upon data of seasons and distances, with an accuracy that winds or waves can but little disturb, but she can move secretly and silently upon her prey. There is no cloud of smoke to track her path by day, and the noiseless action of her submerged Propeller gives no warning to the enemy of her approach by night. Tempests cannot thwart her. Calms cannot delay her progress. By the location of her moving

power below the water-line, it is protected from the missiles of the enemy. She can select her own time and place of attack. She can never be forced into an engagement, and in a thousand situations in which the crippled line of battle ship or the crippled paddle-wheel steamer would be at the mercy of the enemy, the *Princeton* may retire from a superior foe and with her unimpaired moving power, retain a position from which she may mark her very retreat with destruction and death.

Whatever may have been the cause of her policy, whether it is the consequence of accident or foresight, it is certainly fortunate for our own country, that she has not followed the example of the leading European powers in their bold expenditures and experiments in the navigation of the ocean by steam. Millions on millions of pounds have been disbursed by those governments, in the construction of steam-fleets, which, in view of the improvements that physical science has successfully introduced in the *Princeton*, may answer as tenders and transport ships, but must prove utterly useless in a naval engagement. While an ordinary sailing man of war may remain efficient, after receiving a dozen broadsides, a shot in the

right place would completely disable the proudest of the war-steamers that now float under the banners of FRANCE or of ENGLAND.

The construction of the *Princeton*, and the reservation of our means to be expended on the principles that have been successfully applied in that beautiful steamer, place us, in regard to steam navigation in a better position than any other nation of the globe. It may safely be said, that the *Princeton* alone is more than a match for a fleet of paddle-wheel steamers. I am informed that Captain STOCKTON, conscious of the advantages which the genius of ERICSSON has given to steam ships, declared on a recent occasion, that, with twenty steam frigates on the new plan, he would engage to take possession of the British channel and to blockade London itself.

But we should have little cause to contemplate with pleasure the improvements which I have thus imperfectly described, if they could be made to minister merely to the arts of warfare. It is in a different service they assume the most interesting aspect; a service in which they cannot fail to extend the blessings of civilization, and promote the welfare of the great family of man.

I have hitherto considered the Propeller merely

in connection with ships of war; but it must prove of far greater importance in increasing the facilities of pacific intercourse, and in establishing a certain and rapid communication between the kindred nations of the globe. A great change in this respect has already been effected, by the application of steam to the navigation of the ocean; but in consequence of the imperfect action of the paddle-wheel, we have hitherto failed to accomplish a successful co-operation of the powers of wind and steam. By the substitution of the Propeller, these two powers may be harmoniously combined. It is well ascertained that sails cannot be used to any great advantage in ordinary steam-ships. The action of the wind upon the sails careens the vessel; and thus, one paddle-wheel is immersed, while the other is lifted entirely out of the water. A great retardation of speed is the obvious consequence. But the Propeller continues equally as efficient when a ship is upon her beam ends, as when she is perfectly upright; and thus, the full power of the engines may be made to operate, at the same moment, with the entire force of the wind. There is no situation of the ship, in which there is any necessary conflict of these two great agencies of propulsion.

In the event of any derangement of the machinery, or of any circumstances which should require an economical expenditure of fuel, the Propeller may be readily disengaged, and the vessel proceed by the aid of her canvass alone. In the *Princeton*, for instance, such is the connection between the engines and the Propeller, that by simply touching a lever the Propeller is at once liberated. Thus released, it revolves freely on the shaft, and causes a very inconsiderable resistance to the progress of the ship.

Such indeed are the lightness and compactness of the Propeller, and such is the simplicity of the engine by which it is set in motion, that it may well be applied to ordinary sailing vessels as an auxiliary; and it is in this form, doubtless, that the invention is destined to promote the greatest and most beneficial changes in navigation. Indeed it requires but little boldness to predict that the time is not far distant when all vessels, intended for ocean navigation, will be provided with this auxiliary power; and thus proceed steadily to their respective points of destination, with a certainty, regularity and despatch, that will add greatly to the results of human exertion.

In natural connection with the PROPELLER, I

now propose to take a hasty glance at Ericsson's Caloric Engine, which excited so much interest a few years ago in England; and which, if it should be brought into practical operation, will prove the most important mechanical invention ever conceived by the human mind, and one that will confer greater benefits on civilized life than any that has ever preceded it. For the object of it is the production of mechanical power by the agency of heat, at an expenditure of fuel so exceedingly small, that man will have an almost unlimited mechanical force at his command, in regions where fuel may now be said hardly to exist. The announcement of such an idea may startle all those acquainted with the nature of heat, and the well known limits of the amount of mechanical power which any given quantity of caloric is capable of producing; more particularly, as it is a well established fact, that a given quantity of heat will exert an equal amount of mechanical power, to whatsoever medium it may be imparted.

Ericsson's theory of heat is altogether in opposition to the received notion, that the mechanical force produced will bear a direct known proportion to the quantity of caloric generated;

and that the power exerted in our best constructed steam-engines is nearly the measure of that effect.

The late professor HARVEFELDT, of Sweden, one of the first mathematicians of the day, stated in a public lecture, not many years ago, that there is nothing in the theory of heat which proves that a common spirit lamp may not be sufficient to drive an engine of an hundred horse power. It will readily be believed that the professor had but few hearers who did not smile at the suggestion; but among those few we may number ERICSSON, who, from the earliest period of his mechanical labors, had been in the habit of regarding heat as an agent, WHICH, WHILST IT EXERTS MECHANICAL FORCE, UNDERGOES NO CHANGE. This extraordinary fact, ERICSSON exemplifies, by a simple but conclusive illustration; for the readier reception of which, by the audience, it will be well to introduce particular dimensions. Suppose the piston of an ordinary steam-engine cylinder to be at the bottom, and suppose the force of the steam intended to be admitted into this cylinder under the piston to act with the force of 100,000 pounds, which is the force on a piston of 50 inches diameter, acted upon by steam of 50

pounds pressure to the square inch. Suppose the cylinder to be ten feet long, and the piston to be loaded with a weight equal to these 100,000 pounds. If, now, a sufficient quantity of steam of the stated pressure be admitted from below the piston, this load will be elevated through the whole length of the cylinder; and hence we shall have raised a weight of 100,000 pounds through a space of ten feet. But who will contend that this immense amount of mechanical force has required any EXPENDITURE OF HEAT? Does not the steam, after having lifted this weight, contain just as much heat as it did before leaving the steam-boiler—less only the losses by radiation? And does not that heat retain all the properties AFTER the operation which it possessed BEFORE? Am I, then, incorrect in stating that we have obtained this power without changing the nature, or diminishing the energy of the heat employed?

But although nature has furnished us with an agent of such extraordinary properties for the production of mechanical force, how imperfectly do we employ it! In the low-pressure engine we turn the steam, after having performed its good office, into a condensing apparatus where

the heat is in a manner annihilated; and in the high-pressure engine, we throw it away into the atmosphere. Yet men, even of mechanical distinction, ridicule the idea of superseding the steam-engine; and Science seems to pause contentedly in the contemplation of its admitted perfection. For a mere theorist to attempt an exposition of its defects, or to suggest a substitute would, under such circumstances, excite little attention; but the opinions and views, in this connection, of a man of great practical knowledge, who has planned and constructed hundreds of steam-engines, are entitled, certainly, to peculiar consideration.

From what I have already said, it will be readily inferred that the principle forming the basis of the CALORIC ENGINE is that of returning the heat, at each stroke of the piston, and using it over and over again. This is obviously impracticable, if steam is employed as the acting medium. ERICSSON, therefore, uses the permanent gases, and, in preference to all others, atmospheric air. The object which he seeks to accomplish is simply this—that the heat, contained in the air which escapes from the working cylinder, should be effectually taken up by the air

which enters it, at each stroke of the engine. This result Captain ERICSSON has accomplished by means of an apparatus which he styles a regenerator; and so perfectly does it operate, that the heat employed in first setting the engine in motion continues to sustain it in full working force, with no other renewal or addition than may be requisite to supply the inconsiderable loss by radiation. This remarkable invention was first brought before the scientific world in London in the year 1833, though it had been a favorite subject of speculation and reflection with Captain ERICSSON for many years. With the prominent exception of the celebrated Dr. ANDREW URE, and Professor FARAYDAY, now the most distinguished chemists in ENGLAND, nearly all the leading scientific men of the day united in condemning the principle on which it was based as unsound and untenable.

After such preliminary experiments as he deemed requisite to enable him to ascertain the best form of the REGENERATOR, the inventor at once constructed in LONDON a working engine of five horse power, the performance of which was witnessed by a great number of gentlemen of scientific pretensions in that metropolis. Among

others, the popular author, Sir RICHARD PHILLIPS, examined it; and, in his Dictionary of the Arts of Life and of Civilization, he thus notices the result of this experiment. "The author has," he says, "with inexpressible delight, seen "the first model machine of five horse power at "work. With a handful of fuel, applied to the "very sensible medium of atmospheric air, and "a most ingenious disposition of its differential "powers, he beheld a resulting action in narrow "compass, capable of extension to as great forces as ever can be wielded or used by man."

The interest which this subject excited did not escape the British Government. But a short time was permitted to elapse before the Secretary of the Home Department, Lord ALTHORP, now Earl SPENCER, made his appearance in the engine room where the new motive power was in operation. His Lordship was accompanied by Mr. BRUNEL, the constructor of the Thames Tunnel, and a gentleman at one period distinguished for his skill and enterprize as an engineer. At this time he was somewhat advanced in years, and therefore, perhaps, not most judiciously selected by his Lordship to judge of this invention. At the very outset he conceived an altogether

erroneous notion of the nature of the new power, which he would not suffer to be corrected by explanations. An earnest discussion arose between Mr. BRUNEL and the inventor on the spot, which was followed by a protracted correspondence. The result was that an unfavorable impression of the new power was communicated to the British Government.

The invention fared but little better at the hands of Professor FARAYDAY, from whose efficient advocacy and influence the most favorable results might have been anticipated. This gentleman had announced that he would deliver a Lecture on the subject in LONDON, in the spacious theatre of the Royal Institution. The novelty and interest of the invention, combined with the distinguished reputation of the lecturer, had attracted a very large audience, including many individuals of eminent scientific attainments. Just half an hour, however, before he was expected to enlighten this distinguished assembly, the celebrated lecturer discovered that he had mistaken the expansive principle which is the very life of the machine. Although he had spent many hours in studying the CALORIC ENGINE in actual operation, and in testing its

absolute force by repeated experiments, Professor FARAYDAY was compelled to inform his hearers, at the very outset, that he did not know why the engine worked at all. He was obliged to confine himself, therefore, to the explanation of the Regenerator, and the process by which the heat is continually returned to the cylinder, and re-employed in the production of force. To this part of the invention he rendered ample justice, and explained it in that felicitous style to which he is indebted for the reputation he deservedly enjoys, as the most agreeable and successful lecturer in ENGLAND.

Other causes than the misconception of a BRUNEL and a FARAYDAY operated to retard the practical success of this beautiful invention. The high temperature, which it was necessary to keep up in the circulating medium of the engine, and the consequent oxidation, soon destroyed the pistons, valves, and other working parts. These difficulties the inventor endeavored to remedy, in an engine which he subsequently constructed of much larger powers, but without success. His failure in this respect, however, has not deterred him from prosecuting his invention. During his residence in this country,

Captain Ericsson has constructed two engines, though purely experimental, with the view of working at a reduced temperature; and he is gradually, but surely, approaching the realization of his great scheme.

The prescribed limits of a Lecture like the present will not permit me to follow the deeply interesting analogies, traced by Ericsson, between the principle of the Caloric Engine, and that of animate and terrestrial force. Some of his views and calculations on the subject, however, I cannot omit to present to this audience—chiefly to meet the objections of those who imagine that they can detect in the Caloric Engine principles that involve the chimera of the Perpetual Motion.

The sophist accounts for the continued reproduction of the forces expended in nature, by what he calls a nice balance. If this expression fail to convey a distinct idea to those who hear it, it is probably because no very distinct idea on the subject exists in the mind of him who employs it. He imagines that all force exerted in nature is productive of an equivalent counter-force; but how nature makes this counter-force subservient he cannot explain. Were his doctrine true, the

principle of the CALORIC ENGINE would very much resemble that of the Perpetual Motion; for its object is the production of a continued force, almost without reference to the amount of the original exciting cause. Surprising as this may appear, the truth of it is manifested by the principal operating forces in nature, nearly the whole of which, as ERICSSON contends, in a strictly mechanical view, are wasted; or, in other words, are exerted without producing any useful or available counter-effect. And yet Nature has ever at her command an unlimited amount of force!

To illustrate the amount of this force, I will present one or two calculations by ERICSSON that may excite the astonishment of all who have not had their attention particularly directed to this subject. The quantity of water discharged at the Falls of Niagara is estimated at 28,000 tons a second; which is equal to 3,360,000,000 of pounds falling through a space of 150 feet in a minute, or of 504,000,000,000 through the space of *one* foot. If we divide this amount by 33,000, which is the number of pounds that a single horse is capable of moving through the space of one foot in a minute, the result shows the power of the Falls of Niagara to be

equal to 15,000,000 of horse power constantly exerted. Now, an ordinary steam-engine of one horse power, kept constantly at work for one year, consumes twenty tons of coal. To produce by means of steam power, therefore, a constant force, equal to that of the Falls of Niagara, would require the annual consumption of three hundred millions of tons of coal. But the Niagara forms only a small portion of the descent of the St. Lawrence; and the whole earth is watered by rivers and falls, the united force of which amounts to many hundred times that shown by our calculation. What a stupendous force is here exhibited! And yet no one can deny that it is in a mechanical sense entirely lost, and that nature reproduces it constantly by FRESH MEANS. It requires but a word of comment on this illustration, to exhibit the imperfection of the means employed by man for the production of mechanical power. By keeping up a force equivalent to a few millions of horse power in our steam-engines, we are fast exhausting our mineral store-houses; while Nature, in constantly exerting a force a million of times greater, causes no change any where that is perceptible to the most rigid scrutiny. Here, then, we have a CALORIC ENGINE on a

vast scale, and a REGENERATOR that is susceptible of no improvement.

The forces to which I have hitherto alluded, many will ascribe to solar influence; a term by which they merely assign a remote location to the acting cause, but fail to explain it. To meet this class of reasoners, ERICSSON has prepared another calculation, based upon those forces in *animate* nature, for the production of which solar influence is not absolutely necessary. This calculation estimates the amount of force constantly exerted by animate nature, as equivalent to that of an engine of 100,000,000 of horse power. It is well ascertained that man is capable of exerting a force equal to raising 50 pounds through a space of one hundred feet, for every minute during eight hours out of the twenty-four. This force may not be always exerted, but it is within the ability of every man. Hence we shall underrate the *average* individual power, if we state it to be adequate to raising ten pounds constantly through a space of one hundred feet per minute; and, assuming the number of human beings to be 1,000,000,000, their united force will be equal to an engine of 30,000,000 of horse power.

We shall not much err in estimating the force which the quadrupeds are capable of exerting at the same amount; and the inhabitants of the sea are constantly exerting a far greater force. We know that the power of the whale, for instance, frequently exceeds twenty horse, so that the amount assumed would be made up by a million and a half of these creatures alone. It is obvious, then, that the united force of animate beings on our globe is much more than equivalent to an engine of 100,000,000 horse power. It has already been stated that an engine of one horse power consumes 20 tons of coal a year. Hence it follows that with OUR present imperfect means of producing mechanical power, we should require TWO THOUSAND MILLIONS of tons annually to exert a force equal to that of animate nature. To maintain that force, therefore, even on our underrated estimate, for a single century, a mere speck in time, would require two hundred thousand millions of tons; demanding the complete exhaustion of a coal field of 3,000 square miles in extent, with a solid stratum of mineral one hundred feet in thickness. And yet animate nature perpetually maintains this force without any perceptible permanent change.

True it is, we do not know on what mechanical principles it is maintained, nor can we explain the precise cause of animate force; but it would be irrational to attribute it to the arbitrary will of Omnipotence. We cannot but assume that it depends solely on the mechanical laws of nature; and in this view of it we are led, irresistibly, to the conclusion that there exists in Nature a principle of absolute reproduction of mechanical force.

We need not assert that this principle depends on the extraordinary properties of heat which we have been considering. It is enough for our purposes to have demonstrated that Nature exerts an infinite amount of mechanical power without causing any perceptible change. However imperfect may be the principle of ERICSSON'S CALORIC ENGINE, yet it resembles the sublime reproducing principle of Nature, and if not defeated by practical obstacles, this invention will prove a greater boon than the ingenuity of individual man has ever before enabled him to bestow upon his race.